Resources

- "What Is Contextual Learning?"
- "Are You Teaching Mathematics Contextually?"
- Cone of Learning
- Rigor/Relevance Framework
- CTE Academic Standards Crosswalk
- "CTE Math Study Nets Promising Results"

What is Contextual Learning?

What Is Contextual Learning?

What is the best way to convey the many concepts that are taught in a particular course so that all students can use and retain that information? How can the individual lessons be understood as interconnected pieces that build upon each other? How can a teacher communicate effectively with students who wonder about the reason for, the meaning of, and the relevance of what they study? How can we open the minds of a diverse student population so they can learn concepts and techniques that will open doors of opportunity for them throughout their lives? These are the challenges teachers face every day, the challenges that a curriculum and an instructional approach based on contextual learning can help them face successfully.

The majority of students in our schools are unable to make connections between what they are learning and how that knowledge will be used. This is because the way they process information and their motivation for learning are not touched by the traditional methods of classroom teaching. The students have a difficult time understanding academic concepts (such as math concepts) as they are commonly taught (that is, using an abstract, lecture method), but they desperately need to understand the concepts as they relate to the workplace and to the larger society in which they will live and work. Traditionally, students have been expected to make these connections on their own, outside the classroom.

However, growing numbers of teachers today (especially those frustrated by repeated lack of student success in demonstrating basic proficiency on standard tests) are discovering that most students' interest and achievement in math, science, and language improve dramatically when they are helped to make connections between new information (knowledge) and experiences they have had, or with other knowledge they have already mastered. Students' involvement in their schoolwork increases significantly when they are taught why they are learning the concepts and how those concepts can be used outside the classroom. And most students learn much more efficiently when they are allowed to work cooperatively with other students in groups or teams.

Contextual learning is a proven concept that incorporates much of the most recent research in cognitive science. It is also a reaction to the essentially behaviorist theories that have dominated American education for many decades. The contextual approach recognizes that learning is a complex and multifaceted process that goes far beyond drill-oriented, stimulus-and-response methodologies.

According to contextual learning theory, learning occurs only when students (learners) process new information or knowledge in such a way that it makes sense to them in their own frames of reference (their own inner worlds of memory, experience, and response). This approach to learning and teaching assumes that the mind naturally seeks meaning in context, that is, in relation to the person's current environment, and that it does so by searching for relationships that make sense and appear useful.

Building upon this understanding, contextual learning theory focuses on the multiple aspects of any learning environment, whether a classroom, a laboratory, a computer lab, a worksite, or a wheat field. It encourages educators to choose and/or design learning environments that incorporate as many different forms of experience as possible (social, cultural, physical, and psychological) in working toward the desired learning outcomes.

In such an environment, students discover meaningful relationships between abstract ideas and practical applications in the context of the real world; concepts are internalized through the process of discovering, reinforcing, and relating. For example, a physics class studying thermal conductivity might measure how the quality and amount of building insulation material affect the amount of energy required to keep the building heated or cooled. Or a biology or chemistry class might learn basic scientific concepts by studying the spread of AIDS or the ways in which farmers suffer from and contribute to environmental degradation.

Are You Teaching Mathematics Contextually?

Take this self-test and see.

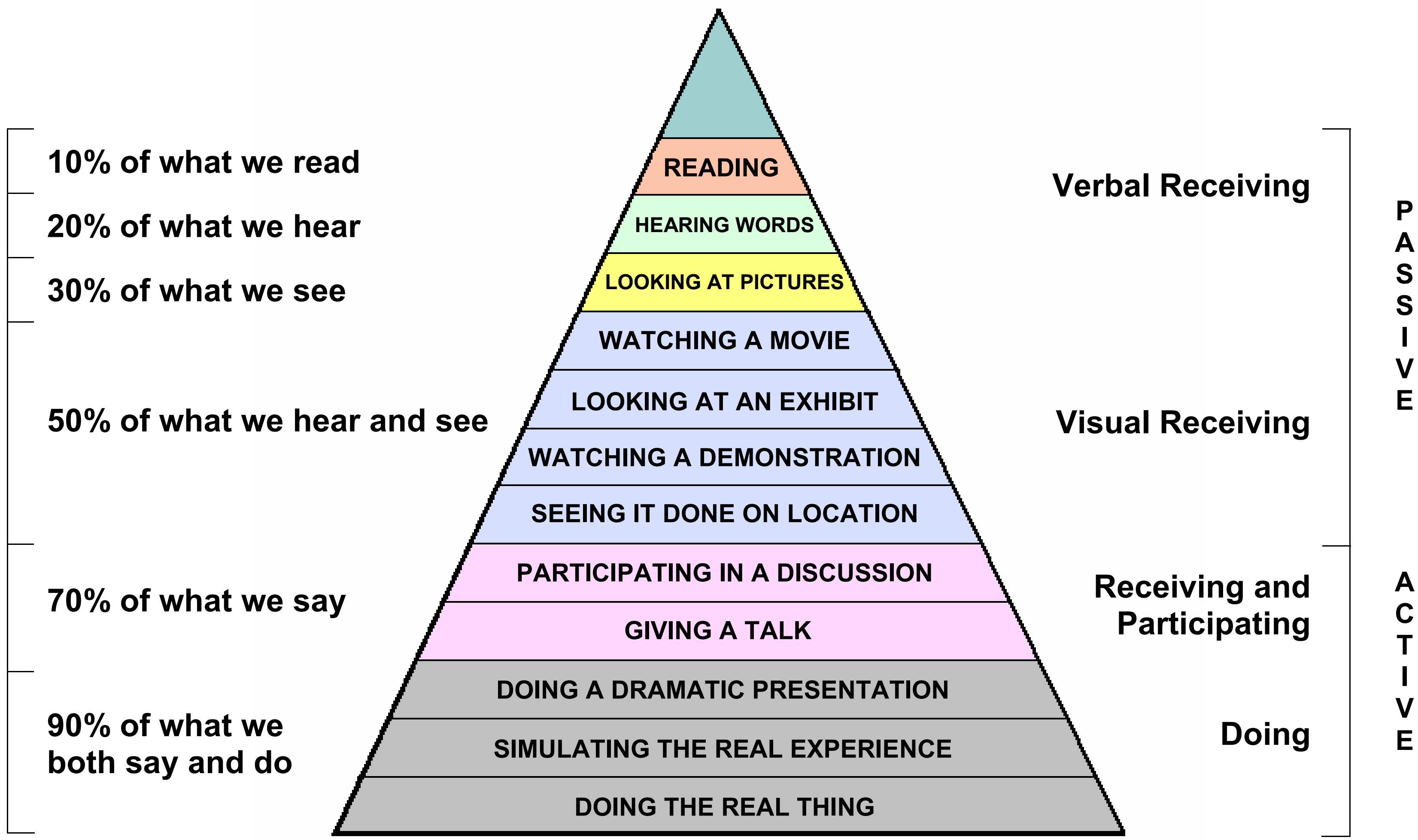
These standards appear to some degree in almost all texts. But *contextual* instruction is rich in all ten standards.

1. Are new concepts presented in real-life (outside the classroom) situations and experiences that are familiar to the student?
2. Are concepts in examples and student exercises presented in the context of their use?
3. Are new concepts presented in the context of what the student already knows?
4. Do examples and student exercises include many real, believable problem-solving situations that students can recognize as being important to their current or possible future lives?
5. Do examples and student exercises cultivate an attitude that says, "I need to learn this"?
6. Do students gather and analyze their own data as they are guided in discovery of the important concepts?
7. Are opportunities presented for students to gather and analyze their own data for enrichment and extension?
8. Do lessons and activities encourage the student to apply concepts and information in useful contexts, projecting the student into imagined futures (e.g., possible careers) and unfamiliar locations (e.g., workplaces)?
9. Are students expected to participate regularly in interactive groups where sharing, communicating, and responding to the important concepts and decision making occur?
10. Do lessons, exercises, and labs improve students' reading and other communication skills in addition to mathematical reasoning and achievement?

CONE OF LEARNING

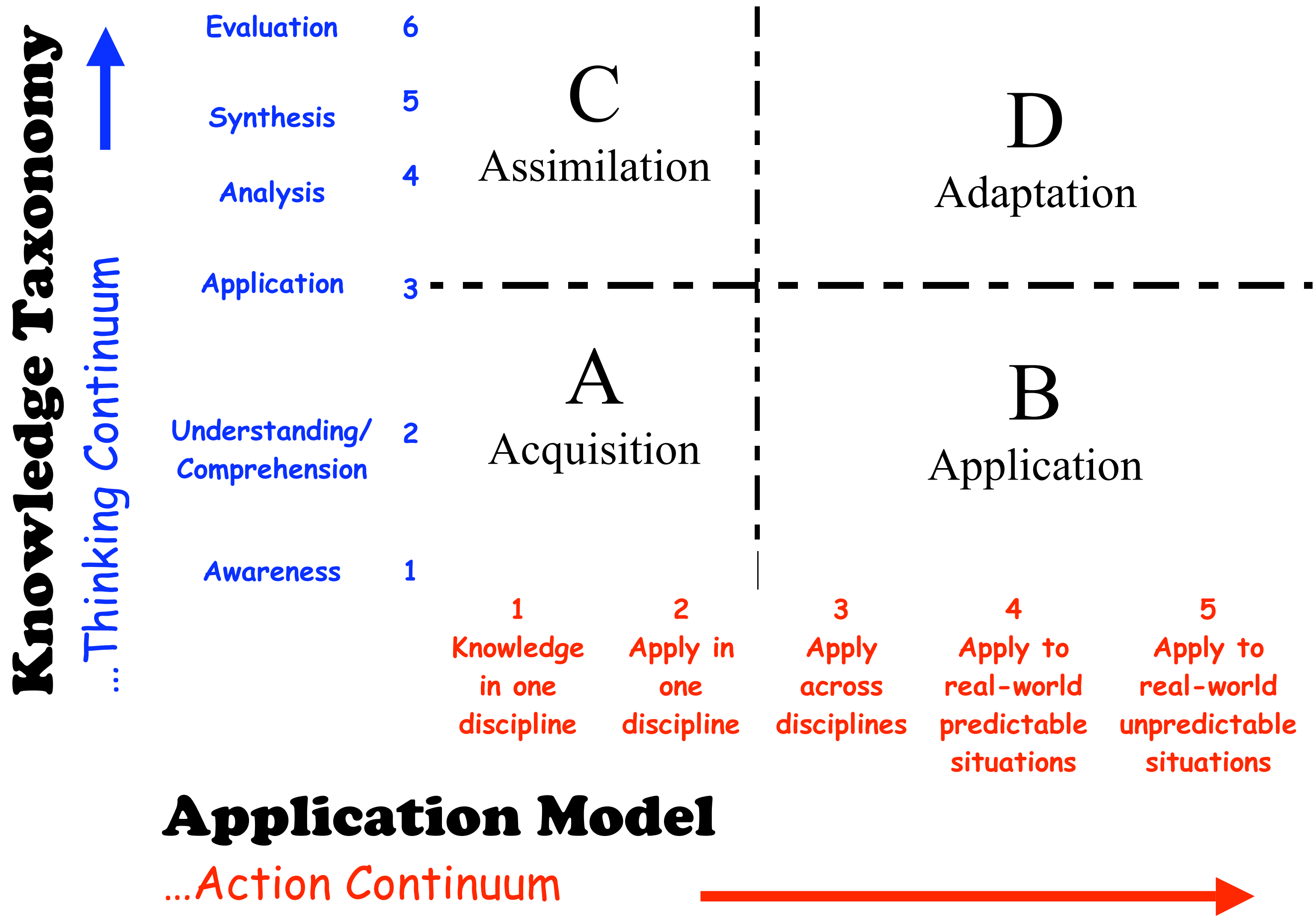
WE TEND TO REMEMBER OUR LEVEL OF INVOLVEMENT

(developed and revised by Bruce Hyland from material by Edgar Dale)



Edgar Dale, *Audio-Visual Methods in Teaching* (3rd Edition). Holt, Rinehart, and Winston (1969).

Rigor/Relevance Framework



International Center for Leadership in Education

Appendix

Career Technical Education and Academic Standards Crosswalk

- Mathematics
- Science
- History–Social Science
- Visual and Performing Arts
- English–Language Arts

Mathematics

Number Sense (Grade Seven)

	Standard	Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
1.1	Read, write, and compare rational numbers in scientific notation (positive and negative powers of 10) with approximate numbers using scientific notation.			X	X	X	X	X	X		X	X	X	X		X
1.2	Add, subtract, multiply, and divide rational numbers (integers, fractions, and terminating decimals) and take positive rational numbers to whole-number powers.			X	X	X	X	X	X		X	X	X	X		X
1.3	Convert fractions to decimals and percents and use these representations in estimations, computations, and applications.			X	X	X	X	X	X		X	X	X	X		X
1.4	Differentiate between rational and irrational numbers.			X	X	X	X	X	X		X	X	X	X		X
1.5	Know that every rational number is either a terminating or a repeating decimal and be able to convert terminating decimals into reduced fractions.			X	X	X	X	X	X		X	X	X	X		X
1.6	Calculate the percentage of increases and decreases of a quantity.			X	X	X	X	X	X		X	X	X	X		X
1.7	Solve problems that involve discounts, markups, commissions, and profit and compute simple and compound interest.		X	X	X	X	X	X	X		X	X	X	X		X
2.1	Understand negative whole-number exponents. Multiply and divide expressions involving exponents with a common base.										X					
2.2	Add and subtract fractions by using factoring to find common denominators.		X								X					
2.3	Multiply, divide, and simplify rational numbers by using exponent rules.		X								X					
2.4	Use the inverse relationship between raising to a power and extracting the root of a perfect square integer; for an integer that is not square, determine without a calculator the two integers between which its square root lies and explain why.										X					
2.5	Understand the meaning of the absolute value of a number; interpret the absolute value as the distance of the number from zero on a number line; and determine the absolute value of real numbers.										X					

Algebra and Functions (Grade Seven)

	Standard	Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
1.1	Use variables and appropriate operations to write an expression, an equation, an inequality, or a system of equations or inequalities that represents a verbal description (e.g., three less than a number, half as large as area A).					X										X
3.4	Plot the values of quantities whose ratios are always the same (e.g., cost to the number of an item, feet to inches, circumference to diameter of a circle). Fit a line to the plot and understand that the slope of the line equals the quantities.					X										X

Measurement and Geometry (Grade Seven)

		Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
1.1	Compare weights, capacities, geometric measures, times, and temperatures within and between measurement systems (e.g., miles per hour and feet per second, cubic inches to cubic centimeters).		X			X				X						X
1.2	Construct and read drawings and models made to scale.		X							X						
1.3	Use measures expressed as rates (e.g., speed, density) and measures expressed as products (e.g., person-days) to solve problems; check the units of the solutions; and use dimensional analysis to check the reasonableness of the answer.									X						
2.4	Relate the changes in measurement with a change of scale to the units used (e.g., square inches, cubic feet) and to conversions between units (1 square foot = 144 square inches or [1 ft^2] = [144 in^2], 1 cubic inch is approximately 16.38 cubic centimeters or [1 in^3] = [16.38 cm^3]).					X							X			X

Statistics, Data Analysis, and Probability (Grade Seven)

		Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
1.1	Know various forms of display for data sets, including a stem-and-leaf plot or box-and-whisker plot; use the forms to display a single set of data or to compare two sets of data.								X			X		X		
1.2	Represent two numerical variables on a scatterplot and informally describe how the data points are distributed and any apparent relationship that exists between the two variables (e.g., between time spent on homework and grade level).								X			X		X		
1.3	Understand the meaning of, and be able to compute, the minimum, the lower quartile, the median, the upper quartile, and the maximum of a data set.								X			X	X	X		

Mathematical Reasoning (Grade Seven)

		Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
1.1	Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, identifying missing information, sequencing and prioritizing information, and observing patterns.				X			X	X	X	X	X		X		
1.2	Formulate and justify mathematical conjectures based on a general description of the mathematical question or problem posed.									X						
1.3	Determine when and how to break a problem into simpler parts.		X							X						
2.1	Use estimation to verify the reasonableness of calculated results.			X	X	X	X	X	X		X	X	X	X		X
2.2	Apply strategies and results from simpler problems to more complex problems.			X	X	X	X	X	X		X	X	X	X		X

Mathematical Reasoning (Grade Seven) *(Continued)*

		Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
2.3	Estimate unknown quantities graphically and solve for them by using logical reasoning and arithmetic and algebraic techniques.			X	X	X	X	X	X		X	X	X	X		X
2.4	Make and test conjectures by using both inductive and deductive reasoning.			X	X	X	X	X	X		X	X	X	X		X
2.5	Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.			X	X	X	X	X	X		X	X	X	X		X
2.6	Express the solution clearly and logically by using the appropriate mathematical notation and terms and clear language; support solutions with evidence in both verbal and symbolic work.			X	X	X	X	X	X		X	X	X	X		X
2.7	Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.			X	X	X	X	X	X		X	X	X	X		X
2.8	Make precise calculations and check the validity of the results from the context of the problem.			X	X	X	X	X	X		X	X	X	X		X
3.1	Evaluate the reasonableness of the solution in the context of the original situation.		X	X	X	X	X	X	X		X	X	X	X		X
3.2	Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.			X	X	X	X	X	X		X	X	X	X		X
3.3	Develop generalizations of the results obtained and the strategies used and apply them to new problem situations.			X	X	X	X	X	X		X	X	X	X		X

Algebra I (Grades Eight Through Twelve)

		Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
1.1	Students use properties of numbers to demonstrate whether assertions are true or false.				X	X	X	X	X		X	X	X	X		X
2.0	Students understand and use such operations as taking the opposite, finding the reciprocal, taking a root, and raising to a fractional power. They understand and use the rules of exponents.						X									
3.0	Students solve equations and inequalities involving absolute values.						X									
4.0	Students simplify expressions before solving linear equations and inequalities in one variable, such as 3(2x-5) + 4(x-2) = 12.			X												
5.0	Students solve multistep problems, including word problems, involving linear equations and linear inequalities in one variable and provide justification for each step.			X		X	X		X			X	X	X	X	X
6.0	Students graph a linear equation and compute the *x*- and *y*- intercepts (e.g., graph 2x + 6y = 4). They are also able to sketch the region defined by linear inequality (e.g., they sketch the region defined by 2x + 6y < 4).												X			

Algebra I (Grades Eight Through Twelve) *(Continued)*

Standard	Description	Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
8.0	Students understand the concepts of parallel lines and perpendicular lines and how those slopes are related. Students are able to find the equation of a line perpendicular to a given line that passes through a given point.					X							X			X
10.0	Students add, subtract, multiply, and divide monomials and polynomials. Students solve multistep problems, including word problems, by using these techniques.	X											X			
12.0	Students simplify fractions with polynomials in the numerator and denominator by factoring both and reducing them to the lowest terms.	X				X	X						X			X
13.0	Students add, subtract, multiply, and divide rational expressions and functions. Students solve both computationally and conceptually challenging problems by using these techniques.	X			X			X	X		X	X		X		
15.0	Students apply algebraic techniques to solve rate problems, work problems, and percent mixture problems.	X	X	X		X	X		X			X	X	X	X	
24.1	Students explain the difference between inductive and deductive reasoning and identify and provide examples of each.		X		X	X		X	X		X	X		X	X	X
24.2	Students identify the hypothesis and conclusion in logical deduction.		X		X			X	X		X	X		X	X	X
24.3	Students use counterexamples to show that an assertion is false and recognize that a single counterexample is sufficient to refute an assertion.		X		X			X	X		X	X		X	X	X
25.1	Students use properties of numbers to construct simple, valid arguments (direct and indirect) for, or formulate counterexamples to, claimed assertions.		X						X			X		X	X	
25.2	Students judge the validity of an argument according to whether the properties of the real number system and the order of operations have been applied correctly at each step.		X						X			X		X	X	
25.3	Given a specific algebraic statement involving linear, quadratic, or absolute value expressions or equations or inequalities, students determine whether the statement is true sometimes, always, or never.		X						X			X		X	X	

Geometry (Grades Eight Through Twelve)

Standard	Description	Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
3.0	Students construct and judge the validity of a logical argument and give counterexamples to disprove a statement.		X													
8.0	Students know, derive, and solve problems involving the perimeter, circumference, area, volume, lateral area, and surface area of common geometric figures.	X		X	X			X			X		X			

Standard		Agriculture	Arts, Media	Building	Education	Energy	Engineering	Fashion	Finance	Health	Hospitality	Information	Manufacturing	Marketing	Public Services	Transportation
Geometry (Grades Eight Through Twelve) *(Continued)*																
10.0	Students compute areas of polygons, including rectangles, scalene triangles, equilateral triangles, rhombi, parallelograms, and trapezoids.	X														
11.0	Students determine how changes in dimensions affect the perimeter, area, and volume of common geometric figures and solids.	X		X		X										X
12.0	Students find and use measures of sides and of interior and exterior angles of triangles and polygons to classify figures and solve problems.	X		X												
15.0	Students use the Pythagorean theorem to determine distance and find missing lengths of sides of right triangles.			X			X									
16.0	Students perform basic constructions with a straightedge and compass, such as angle bisectors, perpendicular bisectors, and the line parallel to a given line through a point off the line.			X									X			
19.0	Students use trigonometric functions to solve for an unknown length of a side of a right triangle, given an angle and a length of a side.			X			X						X			
Algebra II (Grades Eight Through Twelve)																
3.0	Students are adept at operations on polynomials, including long division.						X									
6.0	Students add, subtract, multiply, and divide complex numbers.					X	X									X
Probability and Statistics (Grades Eight Through Twelve)																
3.0	Students demonstrate an understanding of the notion of *discrete random variables* by using them to solve for the probabilities of outcomes, such as the probability of the occurrence of five heads in 14 coin tosses.		X													
8.0	Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line and bar graphs, stem-and-leaf displays, scatterplots, and box-and-whisker plots.	X	X													

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CTE math study nets promising results

A career and technical education curriculum enhanced with mathematics may positively influence students' academic performance, while enhancing their knowledge of technical skills, according to preliminary results from an ongoing research study. A math research project under way at the National Research Center for Career and Technical Education (NRCCTE) at the University of Minnesota is finding that students in classrooms using a math-enhanced CTE curriculum are doing as well as, or outperforming, their contemporaries in key areas such as geometry and algebra. Although the project is ongoing until next year and exact statistical data will not be available until that time, the preliminary findings bode well for CTE, according to Jim Stone, director, NRCCTE.

On global measures in basic math such as geometry and algebra, students in experimental groups in five occupational areas performed better than the control group, Stone told Career Tech Update, although it was not enough to be statistically relevant. But in two of the experiment's six sites, students performed significantly better than their contemporaries in the control group on technical content knowledge, Stone said. Further, on math college placement tests, three-quarters of students in the study performed significantly better than their contemporaries in the control group. The findings suggest that by spending a little more time on the math that is already part of occupational coursework, students can enhance their math and technical skills, Stone said. That is a "totally unexpected finding," he added, because there is the notion that more time spent on academic subjects will compromise the technical content.

"Learning more math helps you in your technical skill and content areas," according to Stone.

The objective of NRCCTE's study is to determine whether teaching mathematics in an applied learning context can enhance learning, and help raise students' math test scores. A 1996 study by the Center for Occupational Research and Development supports this premise, finding that an integrated curriculum is especially important in the teaching of mathematics because students often fail to make a connection between theory and practice. That study found that a successful method to improve students' math skills is through applied learning.

NRCCTE's study is using a random assignment experimental design that involves approximately 135 schools in eight states and a total of 3,000 students. It is conducting five simultaneous replications of the same experiment in five occupational areas: agriculture, information technology, business and marketing, health, and automotive. CTE teachers in the experimental group participated in workshops with math teachers to create enhanced math curricula for use in their classrooms during the spring 2004 semester. Teachers in the control group were asked to teach their CTE classes as usual.

One crucial change made by NRCCTE was developing a curriculum for the experimental

group that points out the intersections between math and CTE. Part of the intervention was introducing math vocabulary that has been broken down from the abstract terminology that is found in textbooks, into language applicable to the occupational context. After students grasp the math content in its occupational context, the math is then reintroduced the way it might show up on a standardized test – in its most abstract form. The demystification of math through applied learning will allow students to understand math principles easier, and they will perform better on standardized tests, researchers hope. This is especially crucial because the No Child Left Behind Act holds schools accountable for student outcomes in core academic areas such as reading, writing and arithmetic. NRCCTE researchers will compare the two groups on math and technical skills at the end of the study in June 2005, and results will be sent to the U.S. Department of Education next fall. The study follows all the precepts of good science in an educational environment that demands science-based research, Stone said, and if the evidence holds up, it should go a long way to proving the value of CTE.

NRCCTE is already looking at the implications to CTE programming if the preliminary data hold up. This might include curriculum redesign that makes better use of the math content in occupational areas, along with enhanced professional development so that teachers can learn how to better work with the math within occupational areas.

The study has spawned at least one interesting consequence: math teachers who worked with NRCCTE to develop the curriculum are now anxious to use it in their own classrooms because it presents math in a new and interesting format. Stone is first to acknowledge that NRCCTE is merely testing a notion that is already being used in schools unrelated to the study. In Massachusetts, for instance, 22 CTE teachers from the Greater New Bedford Regional Vocational-Technical High School (Voc-Tech) are using the trades to help students improve their math skills. Thanks to a grant from the state's Department of Education, CTE teachers are heading back to the classroom to learn how to develop math problems that can help students score better on the statewide Massachusetts Comprehensive Assessment System tests. The project was piloted last year, and after its initial success, the school decided to expand it. About 12 Voc-Tech teachers are participating in after-school courses where they work with math teachers to develop math homework problems specific to their trade areas. Ten more teachers from various CTE programs are expected to enroll in spring 2005.

“One of the strengths in CTE is we can trick students into learning academics by giving them real-world examples to use,” said Luis G. Lopes, Voc-Tech's principal.

Carpentry, medical assistants and engineering technology were the programs involved in the pilot last year, but now most of the 26 programs offered at Voc-Tech will be embracing the new math emersion. The school's math department is also excited by the prospects of using CTE's engaging format to present math to students.

“Traditional teaching methods don't work,” for many of those math teachers, Lopes said. He added that the school is already incorporating the principle in other core subject areas such as reading – with teachers using technical journals to reinforce students' skills. Students are required to read articles related to their technical area of study and take a test that was developed by a CTE and an English teacher. The test helps determine at what grade level students are reading, and how much of the article they understand. As students master reading at one grade level, they proceed to the next level using more advanced technical literature in order to continue improving their reading.